

Effects of Using Trellis Work on Survival and Growth of Medicinal Plant (*Codonopsis Javanica*)

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Abstract

Codonopsis javanica, medicinal plant, has been widely used as a traditional medicine in China, India, Laos, Japan, and Vietnam for treating diabetes and other diseases. This is known as perennial vine/climber, requiring external support for the growing process. This work aimed at investigating the effects of using trellis-work on the survival and growth of *C. javanica* in North Vietnam. There were two treatments as (a) using trellis-work and (b) control/not using trellis-work in planting *C. javanica*. The results indicated that after planting 14 months control (84.5%) had a higher survival rate than using trellis-work (80%), while healthy plants in using trellis-work (55.6%) were higher than that in control (53.7%). The higher shoot number was found in control (2.2), compared to using trellis-work (2.0) after planting 14 months. While plants in using trelliswork (201 cm) were higher than that in control (194 cm). A similar pattern was found in leaf width and length as higher ones were found in using trellis-work (leaves with 6.1 cm length and 4 cm width). It is concluded that using trellis-work led to better growth of *C. javanica* and it is recommended for practical application. However, further study should be conducted to identify the optimum time for making trellis-work.

Keywords: External-support, poverty reduction, production, traditional medicine, vine/climber

1. INTRODUCTION

The medicinal plant has been an important source of medicine throughout the world. Nowadays, it is still widely used for healthcare (WHO, 2002) and is accounted for 25% source of modern medicine (Robinson and Zhang, 2011). The potential and expectation of medicinal plant is prevalent globally. The medicinal plant and traditional knowledge can mitigate the dilemmas between health, economy, environment, and sustainable development caused by rapid globalization (Lambert, 2006; Urrea, 2010). Income from a medicinal plant has been becoming important in developing countries, especially for local people in mountainous areas (Williams et al., 2000; Vodouhe et al., 2008; Torri, 2012). Because of the high commercialization of medicinal plant, it has been over-harvested in the last decades (Chowdhury and Koike, 2010; van Andel and Havinga, 2008), leading to biodiversity loss of medicinal plant species (Walter and Gillett, 1998). The modernization and globalization in developing countries have also been other concerns in the loss of medicinal plant (Case and Pauli, 2005; Quinlan and Quinlan, 2007; Meretika et al., 2010; Voeks, 2007).

Codonopsis javanica (Blume) Hooc.f.et Thoms., a medicinal plant, belongs to family Campanulaceae (IPNI, 2010; Ueda et al., 2002). This plant is known as a perennial climber/vine and distributes in China, India, Laos, Japan, and Vietnam (Nguyen et al., 2014; Nguyen and Joon-Hyeong, 2009). *C. javanica* grows in high moisture soil and mixing with other herbs and climbers. In Vietnam, the species is found in evergreen broadleaved forests on the elevation range of 400-1,600 m (DARD, 2017). The areal stems of *C. javanica* become dead in winter, while rhizome remains alive. In the following year, areal stems will start from rhizome (DARD, 2017). *C. javanica* has been traditionally used to treat diabetes and other diseases. While *C. javanica* root extracts could attenuate fructose-induced hyperinsulinemia and associated oxidative stress (Chen et al., 2013) and extracts also can possess insecticidal action against *Aedes albopictus* (Macchioni et al., 2004).

C. javanica naturally distributes in high mountains in the central region and Northern provinces Vietnam. Commercialization of *C. javanica* has been contributing to poverty reduction in ethnic communities. Therefore, growing *C. javanica* has been concerned in recent years. However, planting technique is still a gap. This work aimed at testing the effect of using trellis-work on the development of *Codonopsis javanica* (Blume) Hooc.f.et Thoms. in northern Vietnam.

2. MATERIALS AND METHOD

2.1. Seedlings

Seedlings were produced by cuttings from rhizomes of *C. javanica*, which were collected from nature in North Vietnam. The seedlings were two months old at the time of the experiment start, which was 13-15 cm height, healthy with one areal stem.

2.2. Experimental Design

The experiment was conducted in North Vietnam at 21°42'52" N and 103°21'17" E on the elevation of 480 m above sea level.

There were two treatments including (a) using trellis-work and (b) control/ without trellis-work. There were three replications in each treatment. A randomized complete block was used in this experiment. Each replication covered an area of 50 m², resulting in a block of 300 m².

Site preparation: vegetation including grasses and herbs shorter than 1 m were completely removed. While higher vegetation and trees remained for shading. The soil was ploughed and dried, and pesticide was applied to the soil 30 days before planting. Fertilization was applied at planting as manure 6 tones + 100 kg Nitrogen + 90 kg Phosphorous + 50 kg Potassium/ha.

The seedling was planted in a hole of 15 cm width by 15 cm length and 20 cm depth. The planting spacing was 50 cm × 50 cm. After planting, no further techniques were applied.

2.3. Data Collection

After planting 14 months, survival and healthy plants were counted for estimating the survival rate in each replication and treatment to generate the corresponding rate.

A number of shoots per plant, height, and stump diameter, and leaf length and width were measured after planting 1, 5, 10 and 14 months for 30 randomly selected plants in each replication.

2.4. Statistical Analysis

Pair-comparison was adopted to evaluate the differences in survival rate, healthy plants, and growth parameters in each measured time between treatments. All analyses were conducted using SAS 9.2 (SAS Institute Inc., Cary, NC, USA).

3. RESULTS

Using trellis-work significantly affected the survival rate (80.0%) of *C. javanica*, which was lower than that (84.5%) of control (no trellis-work). The converse pattern was found in healthy plants as a higher rate (55.6%) was found in using trellis-work, while it was 53.7% in control (Fig. 1).

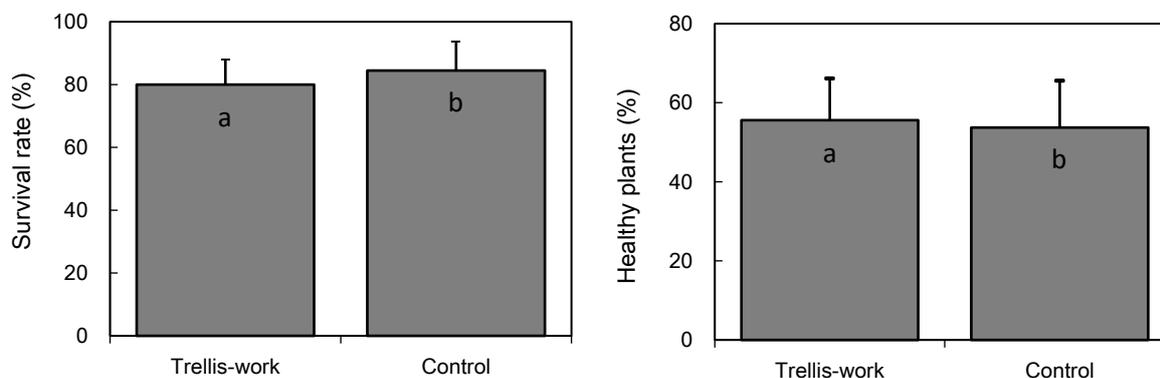


Figure 1. Effect of trellis-work on survival rate and healthy plants at 14 months after planting. Bars indicate +SE. Different letters *a, b* indicate a significant difference of means at $p = 0.05$

The number of shoots increased gradually with ages (Fig. 2). In control, at 1 month after planting it was 1.53 shoots, increasing to 1.70 at 5 months, 2.23 at 10 months, and 2.20 at 14 months. While in using trellis-work, at 1 month after planting it was 1.71 shoots, increasing to 1.73 at 5 months, 2.16 at 10 months, and 2.04 at 14 months. At 1 and 5 months after planting, shoot numbers in using trellis-work were higher than that in control. While at 10 and 14 months after planting, the shoot number in control was higher than that in using trellis-work (Fig. 2).

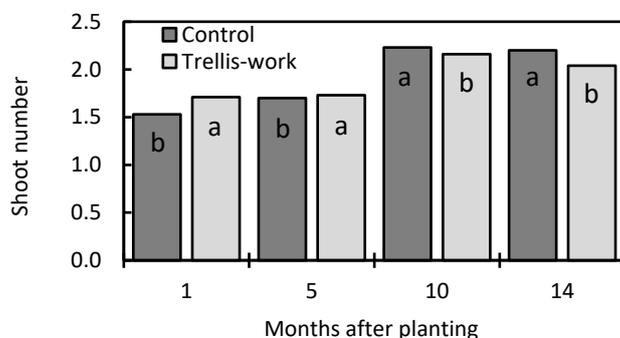


Figure 2. Effect of trellis-work on shoot number. Different letters ^{a, b} indicate a significant difference of means at $p = 0.05$

Using trellis-work significantly affected the height of *C. javanica* (Fig. 3). At 1, 10, and 14 months after planting, the difference was statistically significant. While it was not statistically significant at 5 months after planting. At 1 month, height in control (129.4 cm) was higher than that in using trellis-work (123.7 cm). At 5 months, it was 59.0 cm in control and 57.1 cm in using trellis-work. At 10 months after planting, height in using trellis-work (149.4 cm) was higher than that in control (141.3 cm). At 14 months after planting, height in using trellis-work (201.9 cm) was also higher than that in control (194.0 cm).

The difference of stump diameter between using trellis-work and control was only statistically significant at 1 (1.25 cm in control and 1.24 cm in using trellis-work) and 5 (1.23 cm in control and 1.24 cm in using trellis-work) months after planting. While it was 1.31 cm at 10 months and 1.32 cm at 14 months after planting in both control and using trellis-work (Fig. 3).

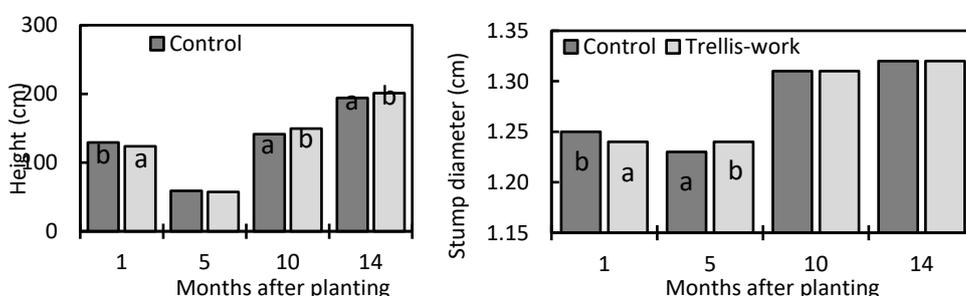


Figure 3. Effect of trellis-work on height and stump diameter. Different letters ^{a, b} indicate a significant difference of means at $p = 0.05$

Using trellis-work (6.16 cm; Fig. 4) had a statistically significant longer leaf length than that in control (5.73 cm). The similarity of difference was found in leaf width as wider in using trellis-work (4.04 cm) and narrower in control (3.88 cm).

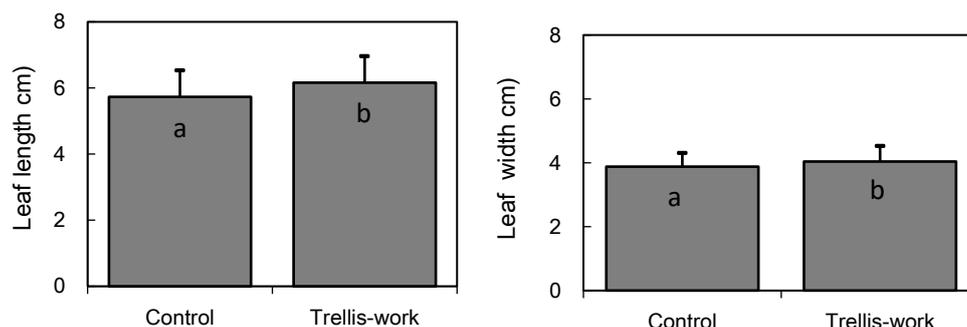


Figure 4. Effect of trellis-work on leaf length and width at 14 months after planting. Bars indicate +SE. Different letters ^{a, b} indicate a significant difference of means at $p = 0.05$

4. DISCUSSION

Climbing plants need to attach themselves to external support to grow vertically to a significant extent and enhance light acquisition. Trellis availability influences climber growth (Garbin et al., 2012), and therefore climbers that fail to encounter a trellis often show reduced growth and/or reproduction. Climbers invest resources in growth at the expense of maintaining the rigidity. To access the light and resources available in the higher forest canopy, climbers demonstrate biomechanical adaptations, allowing them to use external support structures for their benefit (den Dubbelden and Oosterbeek, 1995). There are many different ways that climbers take advantage of their surroundings for climbing (Goriely and Neukirch, 2006) with some major categories as twining, tendril climbing, scrambling, and root climbing (Hegarty, 1991). Of those, *Codonopsis javanica* may belong to twining, tendril climbing. The higher survival rate in control compared to trellis-work could be explained by the small size of seedlings, when they did not require external support/trellis-work and was in a stage of requiring high shading, therefore tendril development for attaching to trellis-work was limited. In addition, artificial trellis-work in the present study may hurt planted *Codonopsis javanica* leading to a higher death rate in trellis-work treatment compared to control (Fig. 1). However, higher healthy plants in trellis-work treatment could be explained by their adaptation and then supported their better growth compared to control. A similar explanation could be applied in the difference of shoot number between trellis-work and control (Fig. 2), indicating a higher shoot number in control when *Codonopsis javanica* was young. Again, adaptation to trellis-work led to taller plants of *Codonopsis javanica* compared to control (Fig. 3).

Climbers devote a large proportion of their energy to the production of leaves to maximize their photosynthetic capabilities, leading to a higher ratio of leaf mass (Castellanos, 1991; Ewers and Fisher, 1991). The large leaf areas and the high conductivity of water offer climbers an advantage in the production of energy by photosynthesis to sustain fast growth rates. Climbers must be able to seek out gaps in the forest, climb tall trees, and rapidly reach the high-light canopy to survive (Castellanos et al., 1989). Because vines lack the rigidity of self-supporting plants, they must depend on their climbing mechanisms to access the light and usurp growing space. The similar results were also found in the present study as larger and wider leaves were found in trellis-work treatment than that in control (Fig. 4). After attaching to trellis-work, it developed faster in leaf area to promote photosynthesis in a higher light environment, supporting higher growth rate and finally it leads to higher production as leaf and stem, and rhizome masses.

The development mechanism of the seedlings of climbers was clearly explained. Seedlings forage for support with the apically dominant shoot in which leaf expansion is suppressed. Internodes of this stem extent, and if it finds potential support, the plant then initiates the climbing mechanism (den Dubbelden and Oosterbeek, 1995). If support is not located and the climber seedling reaches the maximum self-supporting height, a change occurs in the growth strategy. Instead of one apically dominant shoot, the climber develops lateral shoots and stolon's. Enlarged leaves form along stems to capture photosynthetic energy for future growth. The lateral shoots continue to circumnutates, at a lesser growth rate than the one shoot, while the stolon crawl along or under the ground. This vegetative spread allows the vine to persist without vertical ascent while increasing the chance of eventually finding support to climb (den Dubbelden and Oosterbeek, 1995). Once support is located, the vines use different mechanical strategies to achieve vertical growth. The methods that vine species use for climbing affect the type of trellis structure it can climb and the environments in which they best persist (Putz, 1991).

In general, *Codonopsis javanica* is a vine/climber, its growth follows mechanism like other climbers. Therefore, seedlings may not require external support for climbing. However, when it grows larger, external support as trellis-work becomes necessary for survival and higher production. Further study should be conducted on the requirement of external support by different ages for practical application.

5. CONCLUSION

Codonopsis javanica has been contributing to poverty reduction in North Vietnam. Using trellis-work in growing this medicinal plant was studied. The result indicated that at the initial growth stage, trellis-work may not require as control had a higher survival rate and shoot number. However, trellis-work ensured the higher rate of healthy plants and planted *C. javanica* had larger and wider leaves as the product of this medicinal plant. The further study should be conducted to search for a suitable time for setting trellis-work in planting *C. javanica* as generally at initial stage vine/climbers don't require external support. However, it becomes necessary by aging.

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